COLUMBIA SPILLWAY SAMPLER

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COLUMBIA SPILLWAY SAMPLER[1]

by D. L. Rausch and J. D. Haden[2]

Introduction

A sampler has been designed and constructed to fulfill the need of automatically collecting ½-gallon suspended sediment samples from secluded reservoir spillways. This sampler operates most efficiently because the water flows by gravity, and a 12-volt direct current (d.c.) circuit controls the sampling. Samples can be taken on any fixed time interval.

Sedimentation and eutrophication research on small reservoirs frequently requires sampling of the principal spillway discharge around the clock for several days. Because the concentration of sediment and nutrients is usually low, ½-gallon samples are needed to meet laboratory analytical requirements. The seclusion of most reservoir spillways makes it impractical to install alternating current (a.c.) power and inconvenient to carry many large batteries to the sampling site. Therefore, a gravity flow sampler was designed and constructed that automatically collects ½-gallon samples and operates on one 12-volt battery.

The described automatic sampler was developed by the authors, and it is being used at the North Central Watershed Research Unit, Agricultural Research Service, Columbia, Missouri.

Figure 1 shows an overall view of the Columbia sampler, which is capable of automatically collecting as many as 24 samples on any fixed time interval. This sampler operates by gravity flow or velocity head or both of the principal spillway discharge, but the time of sampling is electrically controlled.

A sample is taken when two conditions are met:

[1] In cooperation with the Missouri Agricultural Experiment Station and the Agr. Eng. Dept., Univ. of Mo., Columbia.

[2] Agricultural engineer and engineering technician, Agr. Res. Ser., U.S. Dept. of Agr., Columbia, Mo.

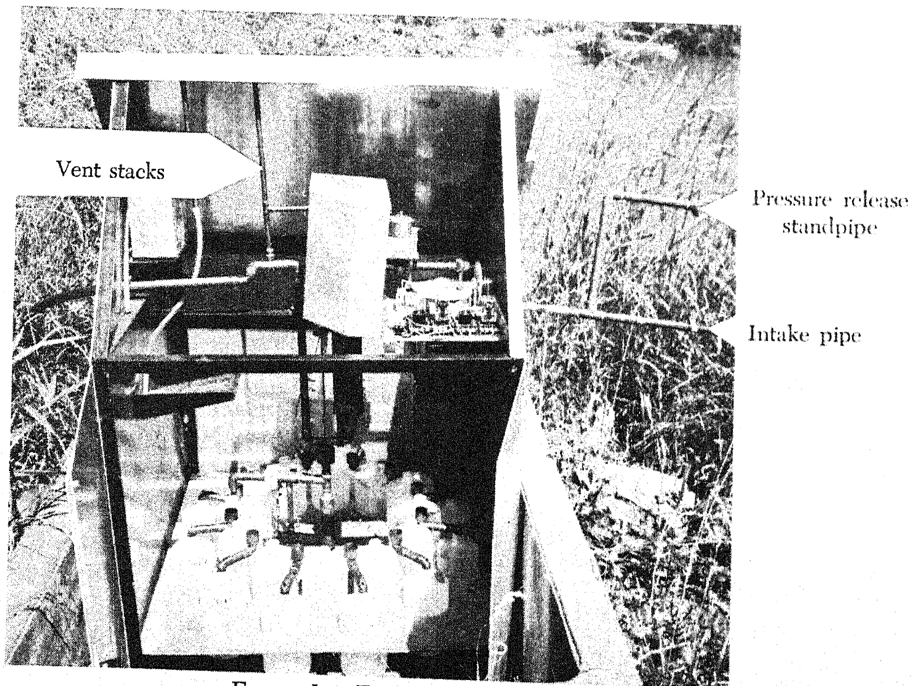


FIGURE 1. — Front view of Columbia sampler.

(1) when the water stage (or water pressure on the intake orifice) is greater than a preset level that closes the water level switch and (2) when the clock switch closes. The sample size is determined by the size of the U-shaped sample trap. Samples are discharged to each bottle through a nozzle which rotates to an empty bottle at the beginning of each sampling cycle. Water flows continuously through the sample trap except during the dumping of the sample.

The main advantages of this sampler are its low power requirements and its large sample volume. Because of the sampler's low power requirements, it can operate on one storage battery for a month, or longer, depending on the number of samples taken and storage time of the battery before its use. Furthermore, this sampler can easily be built with an a.c.-powered circuit.

Description

The water enters the sampler through a plastic pipe connected to the intake (fig. 2). The sampler was installed with its base approximately 4 feet below the intake. Where there is sufficient velocity head, the intake pipe can be level or on a slight incline. This will facilitate drainage and will still permit sufficient flow. The difference in height between the intake and sampler determines when water starts to flow through the sampling system. A schematic of the sampler hardware is shown in figure 3.

The water level switch, figure 4, is constructed of a glass tube bent to form a reservoir for mercury. Single positive and negative wires are placed through the sidewall of the tube, are sealed with an epoxy cement, and are spaced to allow the mercury to cover one electrode. An increase in pressure from a rise in water level in the intake pipe is sensed through a small tube connected to the mercury manometer. As the pressure rises, mercury is forced upward by air trapped between the mercury and water and makes contact with the remaining electrode when the water reaches a preset level, allowing electric current to flow from the 12-volt d.c. automotive-type battery to the clock switch. The pressure required can be adjusted by adding or removing mercury or by tilting the manometer.

The clock switch, figure 5, is actuated by notches in the wheel of the Mercury Instruments Chart Drive — Model 99 Motor rewind clock of a Type S recorder.[3] The spacing of these notches determines the time interval between samples. A stylus marks the time of sampling on the recorder chart.

The shutoff valve (fig. 6) is made from a ¾-inch motorized waterline plug valve modified by attaching a solenoid that rotates 90°. The body is brass, and the plug is stainless steel. This valve prevents overfilling of jugs to ensure uniform sample size. It can be

[3] Installation and Service Manual, Type S Flood Hydrograph Recorder, U.S. Geological Survey, Surface Water Branch, Columbus, Ohio, January 1964.

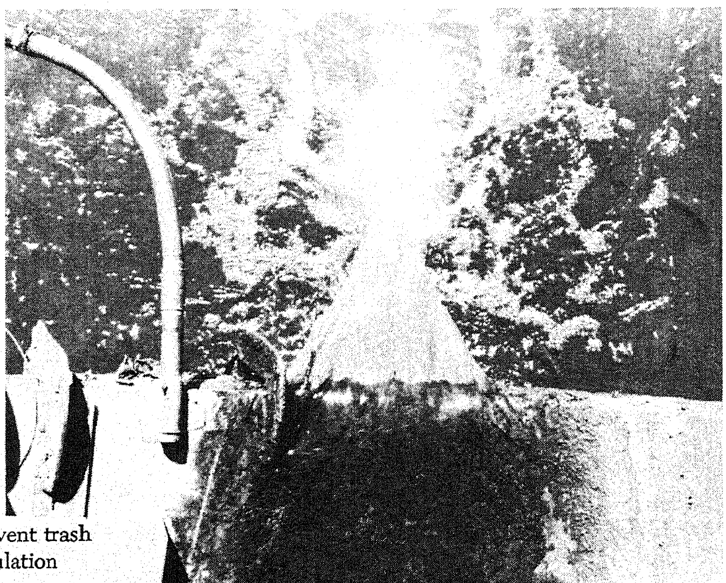


FIGURE 2. — Intake located in the outlet end of the spillway pipe.

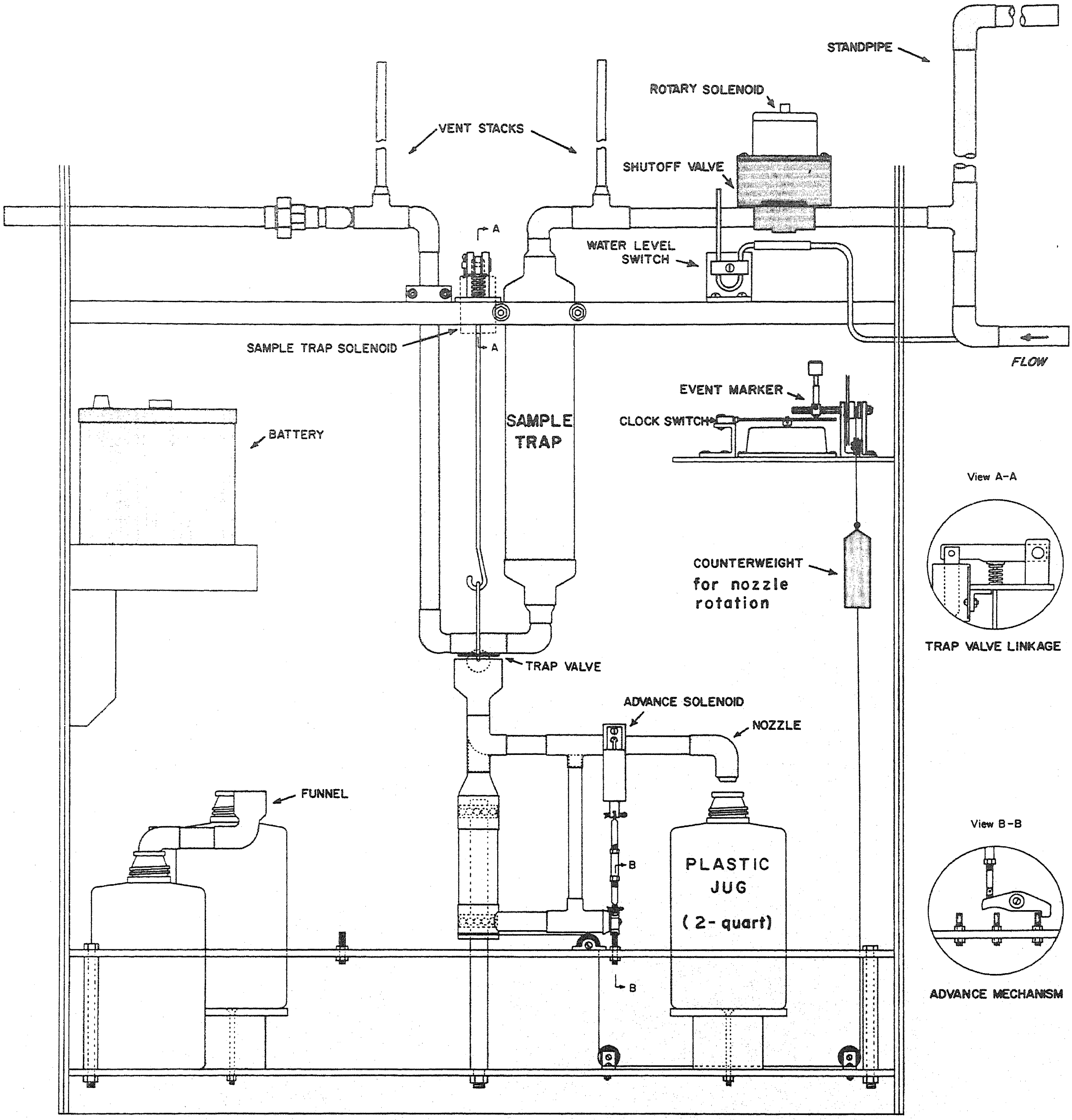


FIGURE 3. — Schematic of sampler hardware.

omitted if the intake pressure does not become excessive or if uniform sample size is not critical.

The sample trap and associated plumbing (fig. 7) are constructed of copper fittings and rigid tubing. The main portion of the sample trap is 3 inches (inside diameter) by 13 inches high. When the solenoid lowers the ball in the trap valve. the sample trap empties and allows the water to flow around it and through the pivoting nozzle into a jug.

Vent stacks are located on the inlet and on the outlet sides of the trap reservoir. Because a closed conduit is used, these vents are necessary to release trapped air in the sample trap when filling. They also allow air to enter when the sample is dumped and break the syphoning effect of water flowing through the outlet of the sampler. A pressure release standpipe on the intake side of the sampler prevents excessive pressure in vent stacks and in the mano-

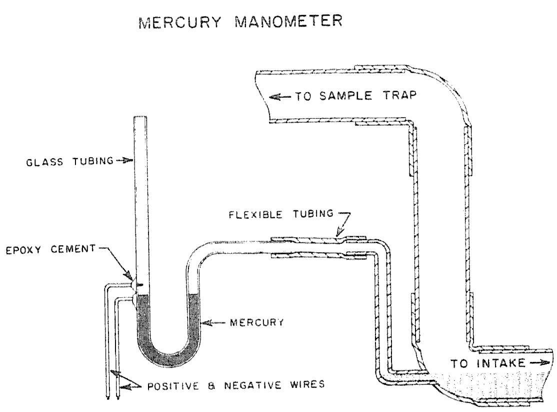


FIGURE 4. — Water level switch.

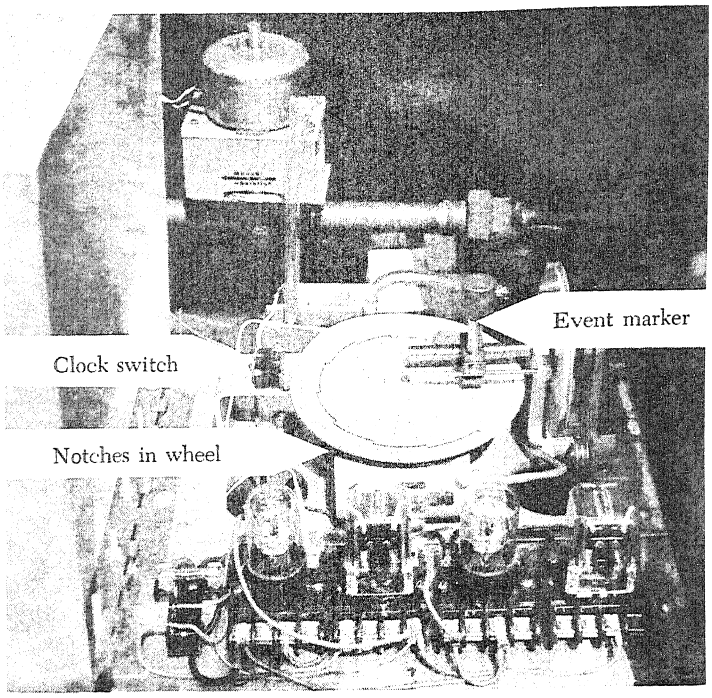


FIGURE 5. — Clock switch and event marker mounted on chart wheel of type S recorder.

meter-type water level switch when the shutoff valve closes.

The sample is distributed to the jugs through a rotating nozzle, pulled forward by a 20-ounce counterweight suspended from a 9-pound test, hard-braid casting line (approximately 0.015-inch diameter). This movement is controlled by the advance solenoid and mechanisms (fig. 3 and 8). The funnels for the outer row of jugs (fig. 1, 8, and 9) are made of ¾-inch elbows and 1¼-inch by ¾-inch reducers. A ¼-inch copper tube is connected from the lower side of the elbow (inside the jug) through the

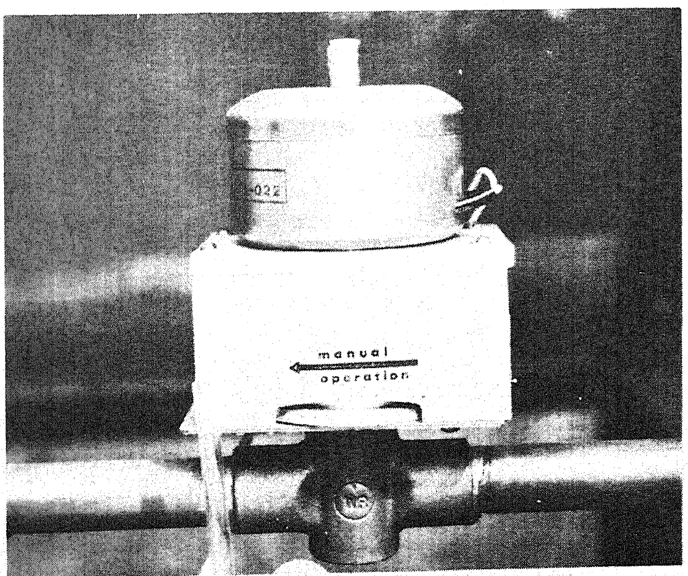


FIGURE 6. — Shutoff solenoid mounted above shutoff valve.

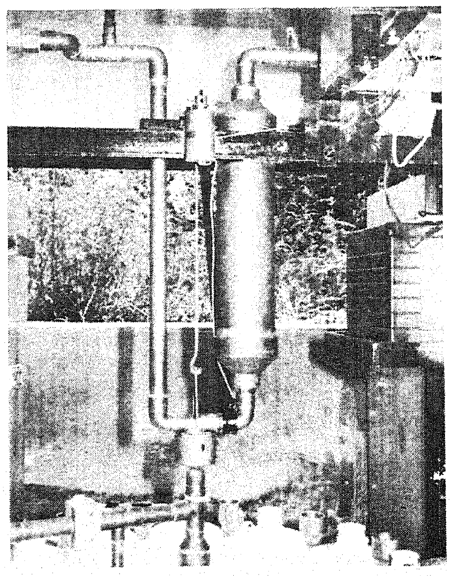


FIGURE 7. — Sample trap with solenoid for opening valv at bottom.

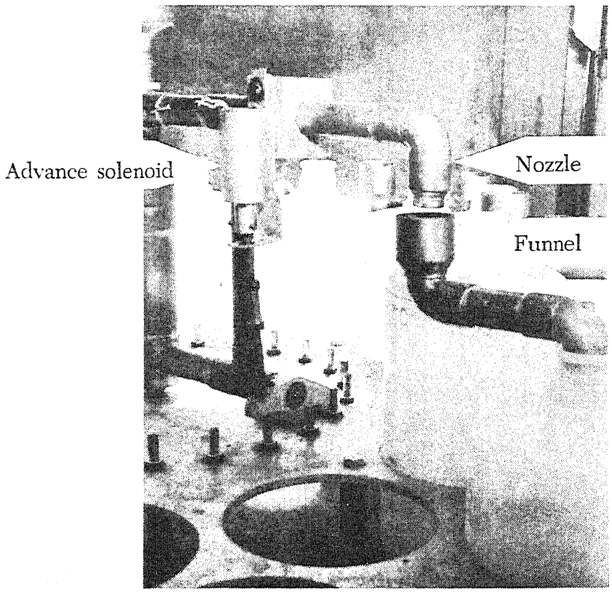


FIGURE 8. — Advance mechanism, nozzle, and funnel and jug (solenoid energized).

top of the elbow, as shown in figure 9. This allows the air in the jugs to escape without obstructing the flow of incoming water.

The sampler can be sheltered in a shed approximately 3 feet square by 5 feet high, as shown in figure 1. Doors on the front and rear and one section of roof open to provide easy access to jugs, battery, and event marker chart. Total weight of the sampler is approximately 150 pounds.

Operation

When the total pressure of water in the intake is great enough to cause flow through the sample trap, the following events occur to complete a sampling cycle:

1. The rising water pressure in the intake pipe closes the water level switch.
2. Notches in the chart wheel actuate the clock switch, figure 5. Rotation of the chart wheel allows the microswitch arm to drop into a notch, completing the circuit to a series of time delays and relays. The electrical circuit is shown in figure 10.
3. When both the water level and clock switches close, relay R1 activates the shutoff and advance solenoids shown in figures 6 and 8. This stops the flow of water through the trap and positions the nozzle over the jug to be filled.
4. After 8 seconds, the time allowed for excess water to flow out of the sample trap, the points of TD-8 open, de-energizing R2 and energizing the solenoid attached to the sample trap valve located at the bottom of the ½-gallon reservoir (fig. 7). The trap is now open, allowing the sample to flow down through the nozzle arm into the jugs or funnel and jugs alternately.
5. After 30 seconds, TD-30 points open, allowing TD-8 and R1 to return to normal positions and the advance, shutoff valve and sample trap solenoids to be de-energized. The heater of TD-30 stays on until the points of the microswitch are opened by the rotation of the timing wheel (approximately 6 minutes).
6. An event marker is actuated by the nozzle driving line wrapped around the counterweight drum of a Type S recorder. The advance of the nozzle arm causes movement of the line and rotation of the screw of the stylus holder, causing the stylus to mark on the chart at the time a sample is taken. The chart in figure 5 shows a typical trace for 10 samples taken 2 hours apart, beginning at 1040 hours.

Options

If a.c. power is available at the sampling site, the electrical circuit can be modified to that shown in figure 11. In this circuit, the relays operate on 115 volts a.c. while the solenoids operate on 100 volts d.c. supplied by a small rectifier. The shutoff solenoid is not included in the circuit, but it can be added parallel to S2 if the intake pressure is expected to be high enough to overfill samples.

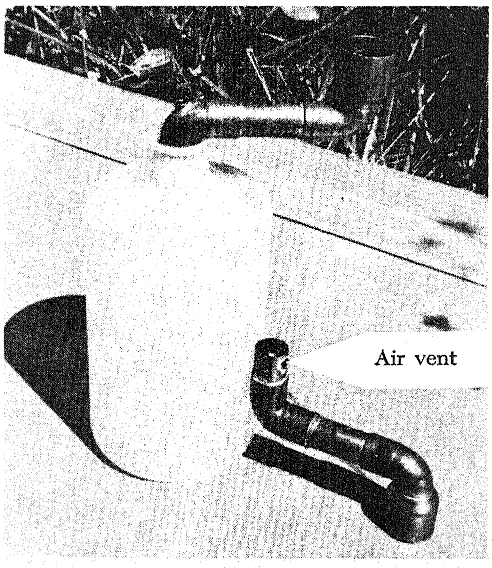


FIGURE 9. — Funnel for outer row of jugs with one inverted to show vent for air to escape during filling.

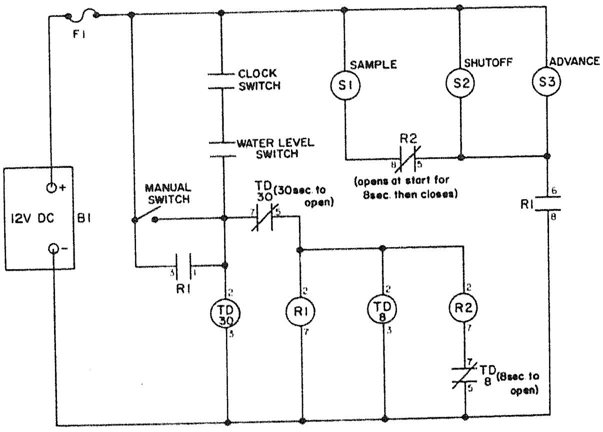
Optional water level switches may be a float-operated micro-switch or a magnetic-operated reed switch. Either type could be used for this sampler when a mercury manometer type is not desireable.

Two samplers have also been installed below modified Parshall flumes on terrace outlets as well as on reservoir spillways. They can be used in other applications — where there is enough relief to provide gravity flow, where the intake velocity is not critical, and where the particles are mostly clay size.

Intake Requirements

The design and placement of the intake for this sampler will determine whether the samples are representative of the stream flow. The desired criterion is for the velocity through the intake (V_i) to equal the stream velocity (V_s). Nelson[4] showed the

ELECTRICAL SCHEMATIC



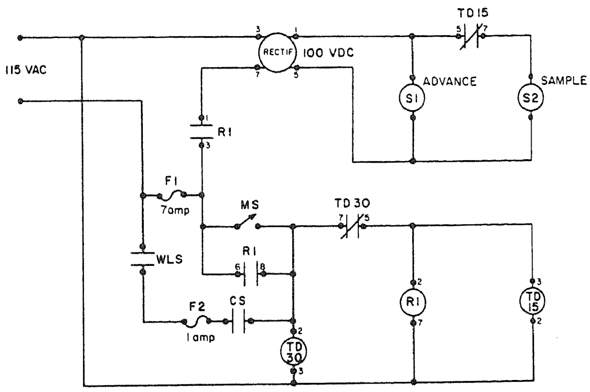
ELECTRICAL PARTS SPECIFICATIONS

NOTATION	FUNCTION	DESCRIPTION
BI	BATTERY	AUTOMOTIVE TYPE, 12 VDC
CL	CHART & TIMING DRIVE	MERCURY INST. MODEL 99
CS	CLOCK SWITCH	ROBERT SHAW ZLD-0037
FI	FUSE	BUSS TYPE 10 AMP
MS	MANUAL BYPASS SWITCH	TOGGLE SWITCH *
RI	RELAY DPDT	UNIVERSAL RELAY 312D10 12V
R2	RELAY DPDT	UNIVERSAL RELAY 312D10 12V
S1	TRAP VALVE CONTROL	LEDEX 174432-024
S2	SHUTOFF VALVE CONTROL	LEDEX S8211-002
S3	NOZZLE ADVANCE CONTROL	LEDEX 171707-008
TD 8	RELAY (8 SEC. TIME DELAY)	AMPERITE 12 C 8
TD 30	RELAY (30 SEC. TIME DELAY)	AMPERITE 12 C 30
WLS	WATER LEVEL SWITCH	MANOMETER TYPE **

* Spring return type
** Handmade

FIGURE 10. — Electrical schematic and parts list.

ELECTRICAL SCHEMATIC



ELECTRICAL PARTS SPECIFICATIONS

NOTATION	FUNCTION	DESCRIPTION
WLS	WATERLEVEL SWITCH	MANOMETER TYPE *
CS	CLOCK SWITCH	ROBERT SHAW 2-LD-0037
FI	FUSE	BUSS TYPE 1 AMP
F2	FUSE	BUSS TYPE 7 AMP
MS	MANUAL BYPASS SWITCH	TOGGLE SWITCH **
RI	RELAY DPDT	CORNELL-DUBILIER 312A10
TD 30	RELAY (30 SEC. TIME DELAY)	AMPERITE 115C30
TD 15	RELAY (15 SEC. TIME DELAY)	AMPERITE 115C15
S1, S2	SOLENOID	LEDEX 174432-028
	RECTIFIER	LEDEX 174488-001

* Handmade
** Spring return type

FIGURE 11. — Alternating current electrical schematic and parts list.

effect of the V_i/V_s ratio and particle-size on the error of sample concentration. The concentration error was less than 10 percent when (1) the particle-size was less than 60 microns, or (2) V_i/V_s was between 0.75 and 1.5. The suspended sediment in reservoir spillways is usually clay (less than 4 microns) — well within the particle-size limits.

The intake shown in this report, figure 2, is a ¾-inch copper pipe directed into the streamflow and connected to 25 feet of ¾-inch plastic pipe with essentially no slope. The intake is located 1 inch from the discharge pipe wall so that enough velocity is obtained to prevent settling out of sediment within the trap. This system gives an approximately constant V_i/V_s ratio of 0.25. This low ratio is of little conse-

[4] Report No. 5, "Laboratory Investigation of Suspended Sediment Samplers," Interagency Committee on Water Resources, Subcommittee on Sedimentation. Martin E. Nelson Editor, U.S. Army Engin. Dist., Corps of Engin., St. Paul Minn., Nov. 1941.

quence because of the fine particle-size (less than 4 microns) being sampled.

The intake velocity (V_i) may be increased by using a smaller intake nozzle, which will decrease the area of flow in the intake and, therefore, the velocity will approach that of the stream. A nozzle of three-eighths of an inch would help increase th V_i/V_s ratio to approximately 1.0; however, the smalle nozzle would have a greater head loss and, thu would offset some of the increase in V_i. The V_i/V ratio will not equal unity unless the hydraulic gradien in the system offsets the friction and entrance losse

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